Telescope Dimensional Stability Study for a Space-based Gravitational Wave Mission

Completed Technology Project (2014 - 2017)

Project Introduction

Gravitational waves are on the brink of discovery all across the frequency spectrum. The Advanced LIGO network will be starting science operations to cover frequencies above 10 Hz. Pulsar timing consortia such as NanoGrav expect to see gravitational waves at frequencies of order 30 nHz (corresponding to a period of a year), and the detection of B-mode polarization in the cosmic microwave background is the subject of multiple current research efforts, including BICEP2 and the Planck Mission. The study of the gravitational universe is the science theme of the L3 launch opportunity of European Space Agency's Cosmic Visions program. However, multiple expected discoveries across the spectrum before the end of the decade will increase the urgency and importance of observing the rich variety of fascinating astrophysical sources in the 0.0001 to 1 Hz band that can be observed only from space. All viable space-based gravitational wave mission concepts use telescope designs with similarly challenging requirements that are slightly different from the usual imaging telescope specifications. Two particularly difficult ones are the dimensional stability and stray light requirements. The telescope is directly in the laser interferometric metrology path and therefore must be dimensionally stable. Picometer level stability over timescales compatible with the measurement band (~ 10,000 seconds) are needed for gravitational wave observations. A sensitive detector and simultaneous transmit/receive operation impose a strong requirement for low levels of stray light. Our previous research has identified an off-axis design as most suitable for achieving low stray light performance, and we are currently working to experimentally validate models that identify particulate contamination of the tertiary and quaternary mirrors as the primary sources of stray light once the surface roughness is sufficiently good. We have also demonstrated dimensional stability of an on-axis silicon carbide metering structure. The next step is to put these key pieces together. We propose to fabricate a telescope with a realistic off-axis design, a metering structure made of flight-like light-weighted materials with high stability mirror mounts, and excellent scattered light performance, and to verify that it can meet the requirements for precision interferometric metrology.

Image Not Available

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Organizational Responsibility

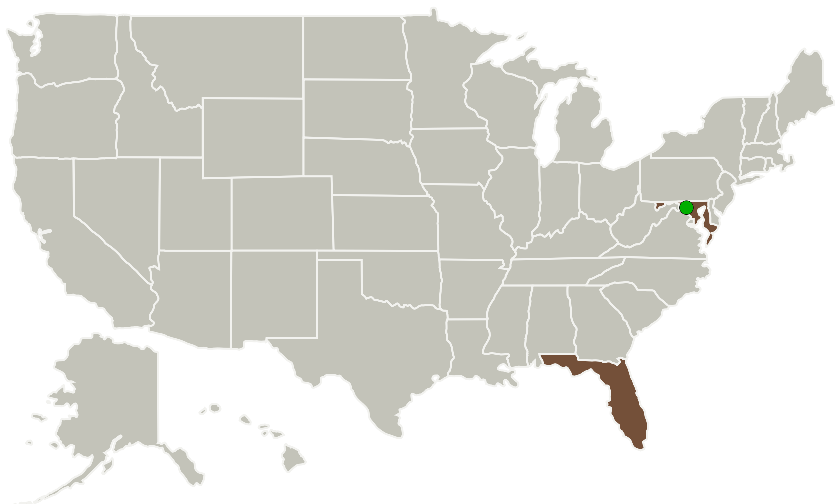
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Strategic Astrophysics Technology

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Florida	Maryland

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

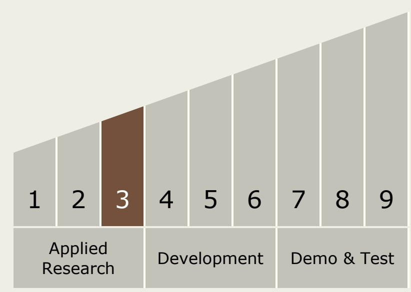
Jeffrey C Livas

Co-Investigators:

David T Leisawitz
Guido Mueller
Lenward T Seals
Vincent T Bly
Joseph M Howard
Peter N Blake
Garrett West
Shannon R Sankar

Technology Maturity (TRL)

Current: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments

Continued on following page.

Technology Areas *(cont.)*

- └ TX08.1 Remote Sensing Instruments/Sensors
  - └ TX08.1.3 Optical Components

Target Destination

Outside the Solar System